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(71) Applicant: Hitachi, Ltd.
Chiyoda-ku, Tokyo 101-8010 (JP)

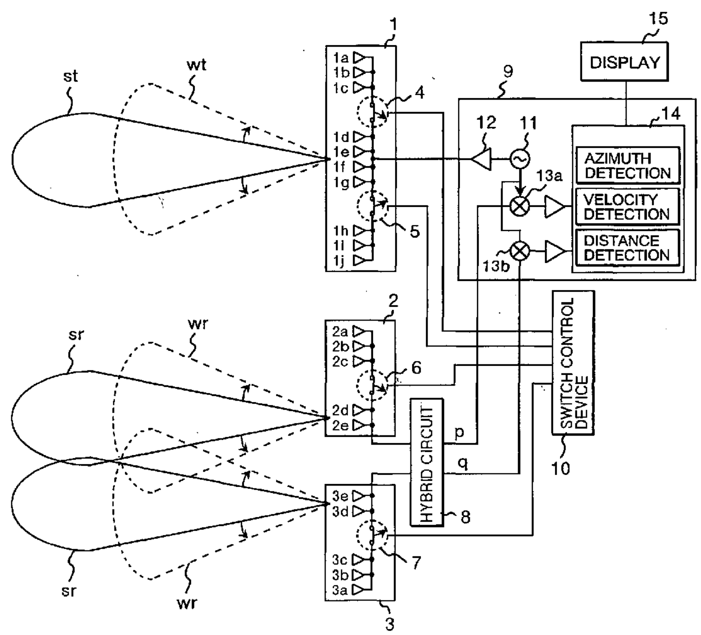
(72) Inventors:
- Shinoda, Hiroshi, Hitachi,Ltd.,Intell.Prop.Group
Chiyoda-ku, Tokyo 100-8220 (JP)
- Kondoh, Hiroshi, Hitachi,Ltd.,Intell.Prop.Group
Chiyoda-ku, Tokyo 100-8220 (JP)

(74) Representative: Beetz & Partner Patentanwälte
Steinsdorfstrasse 10
80538 München (DE)

(54) Monopulse radar system with adjustment of beam width

(57) A monopulse radar system wherein the velocity of a mobile body, distance between an obstacle and the mobile body and relative velocity can be detected and simultaneously, the direction of the obstacle can be detected. A monopulse radar system wherein an azimuth is detected depending upon amplitude difference or phase difference between signals respectively received by plural receiving antennas and an array antenna (1,2,3) composed of plural antenna elements (1a-j,2a-e,3a-e) is used for each transmitting antenna and each receiving antenna, wherein at least one of the transmitting antenna and the receiving antenna is provided with an antenna switch (4,5,6,7) for switching an antenna beam shape to a short angle/long distance or a wide angle/short distance. Also a switch control device (10) that controls the switching of the antenna switch is provided.

FIG. 1



EP 1 321 776 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a monopulse radar system, further detailedly relates to a monopulse radar system that radiates a radio wave, receives a reflected radio wave from a body where the radio wave is detected with plural receiving antennas and detects the direction of the detected body depending upon difference in amplitude or a phase between signals received by the plural receiving antennas and particularly relates to a monopulse radar system suitable for a radar used for a car and mounted on a mobile body such as a vehicle.

Description of the Related Art

[0002] Heretofore, a radar system used for a car and mounted on a mobile body such as a vehicle for detecting the velocity and the position of a detected body such as the mobile body and an obstacle is known. For a radar system used for a car, a radar system used for a car in which antenna beam width is switched from wide one to narrow one and vice versa corresponding to a detected body and the velocity and the position of the detected body are precisely detected and a radar system used for a car in which the direction of the detected body can be detected are developed.

[0003] For a document related to the former, for example, Japanese published unexamined patent application No. Hei 2-287181, "RADAR SYSTEM USED FOR CAR" and Japanese published unexamined patent application No. 2000-258524 can be given.

[0004] For the latter primary radar system for detecting the direction of a detected body, a mechanical scanning system of mechanically turning an antenna by a motor, a beam switching system of switching plural antennas different in the orientation of a beam (for example, disclosed in Japanese published unexamined patent application No. Hei 8-334557) and a monopulse system (for example, described on pages 8 to 19 of "Monopulse Principles and Techniques" published by ArtechHouse and written by Samuel M. Sherman) can be given.

[0005] According to the monopulse system, as shown in FIG. 10, reflected waves 29 from an obstacle 28 are received by two receiving antennas 30 and a sum signal p and a difference signal q are generated in a hybrid circuit 8. Relation between the relative electric power of the generated sum signal p and the generated difference signal q and an azimuth is as shown in FIG. 11 and relation between the ratio t of the sum signal p and the difference signal q and an azimuth is as shown in FIG. 12. As shown in FIG. 12, as the ratio t of the sum signal p and the difference signal q is a monotone decreasing function in relation to an azimuth, the azimuth of a detected body can be uniquely determined based upon the ratio t of the sum signal and the difference signal. High-resolution angle detection can be also performed in a wide range by increasing the number of receiving antennas.

[0006] Recently, it is demanded for a radar system used for a car that the direction of a detected body is precisely detected at the same time as the velocity and the position of the detected body are precisely detected. Further, as the radar system is used for a car, it is demanded that the radar system has simple configuration, is compact and the manufacturing cost is low. The above-mentioned conventional type monopulse system is excellent in azimuth resolution, compared with another system and relative miniaturization is possible. However, antenna beam width is required to be widened to enlarge a detectable directional range, a detectable distance range is narrowed and azimuth resolution is also deteriorated. To enlarge a detectable azimuth without deteriorating detectable distance and azimuth resolution, an antenna that generates a wide angle beam and an antenna that generates a narrow angle beam are required to be provided and to be switched, and there is a problem that the system is large-sized and the cost is increased.

SUMMARY OF THE INVENTION

[0007] Therefore, the invention is made to solve the problem and it is the object to provide a low-cost, compact and light monopulse radar system wherein the monopulse system is improved, a detectable range of the position (distance between an antenna and a detected body) of the detected body and relative velocity can be switched to a sharp angle/long distance or a wide angle/short distance and simultaneously the precise azimuth of an obstacle can be detected in the range.

[0008] To achieve the object, in the monopulse radar system according to the invention, at least one of a transmitting antenna and a receiving antenna is formed by an array antenna composed of plural antenna elements, the plural antenna elements are divided into plural groups, an antenna switch to switch the plural groups is provided and a switch control device to control the opening and closing of the antenna switch is provided to switch an antenna beam of at least the transmitting or receiving antenna to a sharp angle/long distance or a wide angle/short distance.

[0009] In the invention, a detectable range of distance up to a mobile obstacle and relative velocity can be switched to a sharp angle/long distance or a wide angle/short distance by switching the antenna switch of the array antenna, simultaneously the accurate azimuth of the obstacle can be detected in the detectable range and in case antenna beams cover a sharp angle and long distance, higher-accuracy azimuth detection is enabled. As a detection range is switched by connection

and disconnection in units of an antenna element, multiple independent array antennas the orientation of which is determined are not required and the simple antenna switch is provided to the array antenna, the low-cost, compact and light system can be realized.

[0010] Beam switching technique in which the velocity of a detected body such as a mobile body and an obstacle and distance up to it are detected in a state of suitable beam width by switching beam width according to distance up to the detected body (disclosed in for example, Japanese published unexamined patent application No. Hei 2-287181, "RADAR SYSTEM USED FOR CAR") is known, however, according to the beam switching technique, the azimuth of a detected body cannot be detected. In the invention, it is first found and realized by combining beam switching technique and a monopulse radar system that in case antenna beams cover a sharp angle and long distance, higher-accuracy azimuth detection which is not acquired in each of the beam switching technique and the monopulse radar system is enabled, utilizing the advantages of a monopulse radar.

[0011] As a monopulse radar system according to the invention is provided with the antenna switch for switching beams from the transmitting array antenna and the receiving array antenna respectively composed of plural antenna elements to a sharp angle/long distance or a wide angle/short distance, a detectable range of distance up to a mobile obstacle and relative velocity can be switched to a sharp angle/long distance or a wide angle/short distance, as a monopulse system is used, the accurate azimuth of the obstacle can be detected in the range, in case antenna beams cover a sharp angle and long distance, higher-accuracy azimuth detection is enabled, the detectable range is switched by connection and disconnection in units of an antenna element and as plural array antennas are not required, the low-cost, compact and light monopulse radar system can be realized.

[0012] This and other advantages of the present invention will become apparent to those skilled in the art on reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is a block diagram showing a first embodiment of a monopulse radar system used for a car according to the invention;

FIG. 2 shows the characteristics of a sum signal and a difference signal of a monopulse system for explaining the effect of the invention;

FIG. 3 is a block diagram showing a second embodiment of the monopulse radar system used for a car according to the invention;

FIG. 4 is a block diagram showing a third embodiment of the monopulse radar system used for a car according to the invention;

FIG. 5 is a block diagram showing a fourth embodiment of the monopulse radar system used for a car according to the invention;

FIG. 6 is a block diagram showing a fifth embodiment of the monopulse radar system used for a car according to the invention;

FIG. 7 is a block diagram showing a sixth embodiment of the monopulse radar system used for a car according to the invention;

FIG. 8 is a block diagram showing a seventh embodiment of the monopulse radar system used for a car according to the invention;

FIG. 9 is a block diagram showing an eighth embodiment of the monopulse radar system used for a car according to the invention;

FIG. 10 is an explanatory drawing for explaining the monopulse system;

FIG. 11 shows the characteristics of the sum signal and the difference signal of the monopulse system; and

FIG. 12 shows the characteristic of the ratio of the sum signal and the difference signal of the monopulse system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] FIG. 1 is a block diagram showing the configuration of a first embodiment of a monopulse radar system used for a car according to the invention. In this embodiment, a signal is transmitted from a transmitting and receiving device 9 via a transmitting array antenna 1 composed of plural antenna elements 1a to 1j, the signal reflected on an obstacle is received by a first receiving array antenna 2 composed of plural antenna elements 2a to 2e and a second receiving array antenna 3 composed of plural antenna elements 3a to 3e, and a sum signal and a difference signal respectively generated in a hybrid circuit 8 are sent to the transmitting and receiving device 9.

[0015] The configuration of the transmitting and receiving device 9 is identical to that of a heretofore known monopulse radar system. A millimeter-wave signal from an oscillator 11 is applied to the transmitting array antenna 1 via a power amplifier 12. The sum signal p and the difference signal q respectively generated in the hybrid circuit 8 are respectively applied to mixers 13a and 13b, are mixed with a signal output from the oscillator 11, are respectively converted to an intermediate-frequency signal and are respectively input to a signal processing circuit 14. The. signal processing circuit 14 detects the azimuth of a detected body using signals acquired by converting the frequency of the sum signal p and the difference signal q and detects the velocity and the position of the detected body using the sum signal p. The result of the detection is converted to a signal

suitable for an output device 15 such as a display if necessary and is output to the output device 15.

[0016] In this radar system, as a beam shape from/to the transmitting array antenna 1 and the receiving array antennas 2 and 3 is switched to a sharp angle/long distance or a wide angle/short distance, the transmitting array antenna 1 has plural groups of antenna elements 1a to 1c, 1d to 1g and 1h to 1j and antenna switches 4 and 5 for connecting or disconnecting each antenna element group, and the receiving array antennas 2 and 3 respectively have plural groups of antenna elements 2a to 2c and 2d to 2e and plural groups of antenna elements 3a to 3c and 3d to 3e and antenna switches 6 and 7 for connecting and disconnecting each antenna element group. Further, a switch control device 10 that controls the turning on or off of the antenna switches 4 to 7 is provided.

[0017] For example, when the antenna switches 4 to 7 are turned on by the switch control device 10 and the plural antenna elements 1a to 1j, 2a to 2e and 3a to 3e are connected, a beam shape from the transmitting array antenna 1 is turned a sharp angle/long distance as shown by full lines st and sr in FIG. 1 and as antenna aperture length is reduced when the antenna switches 4 to 7 are turned off, that is, the antenna switches 4 to 7 are disconnected from the groups of antenna elements respectively composed of plural antenna elements 1a to 1c, 1h to 1j, 2a to 2c and 3a to 3c, a beam shape from/to the transmitting array antenna 1 and the receiving array antennas 2 and 3 is turned a wide angle/short distance as shown by dotted lines wt and wr in FIG. 1. As described above, the detectable range of distance up to a mobile obstacle and relative velocity can be switched to a sharp angle/long distance or a wide angle/short distance by switching the antenna switches 4 to 7.

[0018] As in this embodiment, a monopulse system is used, the accurate azimuth of an obstacle can be detected in the range and in case antenna beams cover a sharp angle and long distance, higher-accuracy azimuth detection is enabled. That is, as shown in FIG. 2, when an antenna beam shape is switched, the relation tw of a monotone decreasing function tw when an antenna beam shape is a wide angle/short distance is kept for relation between the ratio t of a sum signal p and a difference signal q and an azimuth and as the inclination of the ratio of the sum signal p and the difference signal q is abrupt as a curve ts in case an antenna beam shape is a sharp angle/long distance, an azimuth can be precisely detected.

[0019] As a detection range is switched by connection and disconnection in units of the antenna element and plural array antennas are not required, the low cost, miniaturization and lightening can be realized. The antenna switches 4 to 7 are not particularly required to be interlocked and various detection ranges can be acquired by individually switching.

[0020] Various detection ranges can be acquired by increasing the number of the antenna elements and the antenna switches respectively shown in FIG. 1 or by varying the ratio of the transmitting array antenna 1 and the receiving array antennas 2 and 3 and azimuth resolution can be enhanced. In this embodiment, the two receiving array antennas are provided, however, the similar various detection ranges can be acquired and azimuth resolution can be enhanced by increasing the number.

[0021] FIG. 3 is a block diagram showing the configuration of a second embodiment of the radar system according to the invention. A monopulse radar system used for a car equivalent to this embodiment is characterized in that an antenna beam shape is switched by only a transmitting antenna 1, the configuration and the control of receiving antennas 2 and 3 are simplified, the system is simplified and the cost is reduced.

[0022] A signal is transmitted from a transmitting and receiving device 9 via the transmitting array antenna 1 composed of plural antenna elements 1a to 1j, the signal reflected on an obstacle is received by the receiving array antenna 2 composed of plural antenna elements 2a to 2e and the receiving array antenna 3 composed of plural antenna elements 3a to 3e, a sum signal and a difference signal respectively generated in a hybrid circuit 8 are sent to the transmitting and receiving device 9, and the velocity of a mobile body, the direction of an obstacle, distance up to the mobile body and relative velocity are detected. In this radar system, antenna switches 4 and 5 for connecting and disconnecting antenna element groups respectively composed of plural antenna elements 1a to 1c and 1h to 1j for switching a beam shape from the transmitting array antenna 1 to a sharp angle/long distance or a wide angle/short distance and a switch control device 10 that controls the turning on or off of the antenna switches 4 and 5 are provided.

[0023] For example, when the antenna switches 4 and 5 are turned on by the switch control device 10 and the plural antenna elements 1a to 1j are connected, a beam shape from the transmitting array antenna 1 is turned a sharp angle/long distance as shown by a full line st in FIG. 3 and as antenna aperture length is reduced when the antenna switches 4 and 5 are turned off, that is, antenna element groups respectively composed of the plural antenna elements 1a to 1c and 1h to 1j connected by the antenna switches 4 and 5 are disconnected, a beam shape from the transmitting array antenna 1 is turned a wide angle/short distance as shown by a dotted line wt. As described above, the detectable range of distance up to a mobile obstacle and relative velocity can be switched to a sharp angle/long distance or a wide angle/short distance by switching the antenna switches 4 and 5. Various detection ranges can be acquired by increasing the number of the antenna elements and the antenna switches respectively shown in FIG. 4 or by varying the ratio of antenna elements in the transmitting array antenna 1 and the receiving array antennas 2 and 3 and azimuth resolution can be en-

hanced. In this embodiment, the two receiving array antennas are provided, however, the similar various detection ranges can be acquired and azimuth resolution can be enhanced by increasing the number.

[0024] FIG. 4 is a block diagram showing the configuration of a third embodiment of the radar system according to the invention. A monopulse radar system used for a car equivalent to this embodiment is characterized in that an antenna beam shape is switched by only a receiving antenna, the configuration and the control of a transmitting antenna are simplified, the system is simplified and the cost is reduced.

[0025] A signal is transmitted from a transmitting and receiving device 9 via a transmitting array antenna 1 composed of plural antenna elements 1a to 1j, the signal reflected on an obstacle is received by a receiving array antenna 2 composed of plural antenna elements 2a to 2e and a receiving array antenna 3 composed of plural antenna elements 3a to 3e, a sum signal and a difference signal respectively generated in a hybrid circuit 8 are sent to the transmitting and receiving device 9, and the velocity of a mobile body, the direction of an obstacle, distance up to the mobile body and relative velocity are detected. In this radar system, antenna switches 6 and 7 for connecting and disconnecting antenna element groups respectively composed of plural antenna elements 2a to 2c and 3a to 3c for switching a beam shape to the receiving array antennas 2 and 3 to a sharp angle/long distance or a wide angle/short distance and a switch control device 10 that controls the turning on or off of the antenna switches 6 and 7 are provided. The configuration of the transmitting and receiving device 9 is identical to that shown in FIG. 1 and the description is omitted. For another component, the same reference number as that in FIG. 1 is allocated to the substantially same component as that shown in FIG. 1. In the other embodiments described afterward, it is identical.

[0026] For example, when the antenna switches 6 and 7 are turned on by the switch control device 10 and the plural antenna elements 2a to 2e and 3a to 3e are respectively connected, a beam shape to the receiving array antennas 2 and 3 is respectively turned a sharp angle/long distance as shown by a full line in FIG. 4 and as antenna aperture length is reduced when the antenna switches 6 and 7 are turned off, that is, the antenna switches 6 and 7 respectively disconnect antenna element groups respectively composed of plural antenna elements 2a to 2c and 3a to 3c, a beam shape to the receiving array antennas 2 and 3 is respectively turned a wide angle/short distance as shown by a dotted line in FIG. 4. As described above, the detectable range of distance up to a mobile obstacle and relative velocity can be switched to a sharp angle/long distance or a wide angle/short distance by switching the antenna switches 6 and 7.

[0027] Various detection ranges can be acquired and azimuth resolution can be enhanced by increasing the number of the antenna elements and the antenna switches respectively shown in FIG. 4 or by varying the ratio of the transmitting array antenna 1 and the receiving array antennas 2 and 3. In this embodiment, the two receiving array antennas are provided, however, the similar various detection ranges can be acquired and azimuth resolution can be enhanced by increasing the number.

[0028] FIG. 5 is a block diagram showing the configuration of a fourth embodiment of the radar system according to the invention. A monopulse radar system used for a car equivalent to this embodiment is characterized in that the system is simplified and the cost is reduced by sharing a transmitting antenna and a receiving antenna.

[0029] A signal is transmitted or received via the transmitting and receiving common array antennas 11 and 12 respectively composed of plural antenna elements 11a to 11e and 12a to 12e by a transmitting and receiving device 9, and the velocity of a mobile body, the direction of an obstacle, distance up to the mobile body and relative velocity are detected by a sum signal and a difference signal respectively generated in a hybrid circuit 8. In this radar system, antenna switches 6 and 7 for connecting and disconnecting antenna element groups respectively composed of the plural antenna elements 11a to 11c and 12a to 12c for switching a beam shape from/to the transmitting and receiving common array antennas 11 and 12 to a sharp angle/long distance or a wide angle/short distance and a switch control device 10 that controls the turning on or off of the antenna switches 6 and 7 are provided.

[0030] For example, when the antenna switches 6 and 7 are turned on by the switch control device 10 and the plural antenna elements 11a to 11e and 12a to 12e are respectively connected, a beam shape from/to the transmitting and receiving common array antennas 11 and 12 is turned a sharp angle/long distance as shown by a full line in FIG. 5 and as antenna aperture length is reduced when the antenna switches 6 and 7 are turned off, that is, antenna element groups respectively composed of the plural antenna elements 11a to 11c and 12a to 12c are respectively disconnected, a beam shape from/to the transmitting and receiving common array antennas 11 and 12 is respectively turned a wide angle/short distance as shown by a dotted line in FIG. 5. As described above, the detectable range of distance up to a mobile obstacle and relative velocity can be switched to a sharp angle/long distance or a wide angle/short distance by switching the antenna switches 6 and 7. In this embodiment, the two transmitting and receiving common array antennas are provided, however, the similar various detection ranges can be acquired and azimuth resolution can be enhanced by increasing the number.

[0031] FIG. 6 is a block diagram showing the configuration of a fifth embodiment of the radar system according to the invention. This embodiment is characterized in that a timing control device 23 is provided to the first embodiment shown in FIG. 1 and a signal for switch-

ing antenna switches 4 to 7 is output to a switch control device 10 every fixed time. A detection range is respectively switched by switching the antenna switches 4 to 7 every fixed time, and the error recognition of an obstacle and undetection can be prevented. It is described above that in the fifth embodiment, the timing control device 23 is provided to the first embodiment, however, it need scarcely be said that the fifth embodiment can be also applied to the second to fourth embodiments.

[0032] FIG. 7 is a block diagram showing the configuration of a sixth embodiment of the radar system according to the invention. A radar system used for a car equivalent to this embodiment is characterized in that the velocity of a mobile body itself is also detected. This embodiment is characterized in that a velocity judgment device 24 is provided to the first embodiment shown in FIG. 1, the velocity of a mobile body on which the radar system is mounted is judged based upon the output of a transmitting and receiving device 9 and a switch control device 10 controls the switching of antenna switches 4 to 7 according to the output of the velocity judgment device 14. Concretely, as the detection of a remote obstacle and the prevention of an unnecessary reflected wave from the vicinity of the mobile body are required when the velocity of the mobile body is fast for example, the antenna switches 4 to 7 are respectively turned on to turn a beam shape to a sharp angle/long distance, and as a remote obstacle is conversely not required to be detected and an obstacle in the vicinity of the mobile body is required to be detected when the velocity of the mobile body is slow, the antenna switches 4 to 7 are respectively turned off to turn a beam shape to a wide angle/short distance. If the number of antenna elements and the switches is increased, a few beam shapes can be switched according to the velocity of the mobile body. As described above, optimum obstacle detection according to the velocity of the mobile body is enabled.

[0033] The case that a beam shape is switched according to the velocity of the mobile body on which the radar system is mounted is described above, however, needless to say, a beam shape can be also switched according to relative velocity with an obstacle. Further, it is described above that in the sixth embodiment, the velocity judgment device 14 is provided to the first embodiment, however, the sixth embodiment can be also applied to the second to fourth embodiments.

[0034] FIG. 8 is a block diagram showing the configuration of a seventh embodiment of the radar system according to the invention. This embodiment is characterized in that a distance judgment device 25 is provided to the first embodiment shown in FIG. 1, distance between a mobile body and an obstacle is judged based upon the output of a transmitting and receiving device 9 and the operation of a switch control device 10 is controlled based upon the output of the distance judgment device 25. For example, in case distance between the mobile body on which the radar system is mounted and the obstacle is long, a beam shape is turned a sharp angle/long distance to enable detecting the remote obstacle and in case distance between the mobile body and the obstacle is short, a beam shape is turned a wide angle/short distance to enable detecting only the obstacle in the vicinity of the mobile body. It is described above that in the seventh embodiment, the distance judgment device 25 is provided to the first embodiment, however, the seventh embodiment can be also applied to the second to fourth embodiments.

[0035] FIG. 9 is a block diagram showing the configuration of an eighth embodiment of the radar system according to the invention. This embodiment is characterized in that a position judgment device 26 is provided to the first embodiment shown in FIG. 1, position information from a position information retrieval system 27 such as a car navigation system mounted on a mobile body is judged by the position judgment device 26 and the operation of a switch control device 10 is controlled based upon the output of the position judgment device 26. For example while a mobile body on which a radar system and a car navigation system are mounted runs on a highway, a beam shape is turned a sharp angle/long distance to enable detecting a remote obstacle and while the mobile body runs on a general road in an urban area, a beam shape is turned a wide angle/short distance to enable detecting obstacles in a wide range in the vicinity of the mobile body.

[0036] It is described above that in the eighth embodiment, the position judgment device 26 is provided to the first embodiment, however, the eighth embodiment can be also applied to the second to fourth embodiments.

[0037] The array antennas in the first to eighth embodiments are formed on a dielectric substrate. For example, a patch antenna and a tri-plate antenna are used, a simple device such as FET is mounted on plural patch groups on the substrate as the antenna switch, a driving power source formed by a simple device such as FET can be simply built so that a driving signal is supplied from the rear surface via the dielectric substrate and miniaturization, lightening and the reduction of the cost are further enabled.

[0038] Miniaturization, lightening and the reduction of the cost can be further expected by using MMIC formed by a semiconductor device for the antenna switch in each embodiment. A beam shape can be efficiently switched by using a mechanical switch the loss of which is low when the mechanical switch is turned on and which completely isolates when it is turned off for the antenna switch. In the above-mentioned each embodiment, the radar system used for a car is described, however, it is clear that the radar system can be used for application except a vehicle.

[0039] Various other modification will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein.

Claims

1. A monopulse radar system that detects an azimuth depending upon amplitude difference or phase difference between signals respectively received by plural receiving antennas, wherein:

   an array antenna (1, 2, 3) composed of plural antenna elements (1a - j, 2a - e, 3a - e) is used for each of a transmitting antenna and the receiving antenna;
   at least one of the transmitting antenna and the receiving antenna is provided with an antenna switch (4, 5, 6, 7) for switching an antenna beam shape to a sharp angle/long distance or a wide angle/short distance; and
   a switch control device (10) that controls the switching of the antenna switch is provided.

2. A monopulse radar system according to claim 1, wherein:

   when the antenna switch connects or disconnects antenna element groups forming the array antenna, an antenna beam shape is switched to a sharp angle/long distance or a wide angle/short distance.

3. A monopulse radar system according to claim 1, wherein:

   the transmitting and receiving antenna is formed by a transmitting and receiving common antenna composed of plural antenna elements.

4. A monopulse radar system according to claim 1, comprising:

   a switch control device that controls the switching of the antenna switch every fixed time.

5. A monopulse radar system according to claim 1, comprising:

   a switch control device that controls the switching of the antenna switch according to distance between a mobile body and an obstacle.

6. A monopulse radar system used for a car that detects an azimuth depending upon amplitude difference or phase difference between signals respectively received by plural receiving antennas, wherein:

   an array antenna (1, 2, 3) composed of plural antenna elements (1a - j, 2a - e, 3a - e) is used for each transmitting antenna and each receiving antenna;
   at least one of the transmitting antenna and the receiving antenna is provided with an antenna switch (4, 5, 6, 7) for switching an antenna beam shape to a sharp angle/long distance or a wide angle/short distance; and
   a switch control device (10) that controls the switching of the antenna switch according to position information from a position information retrieval system mounted on a mobile body is provided.

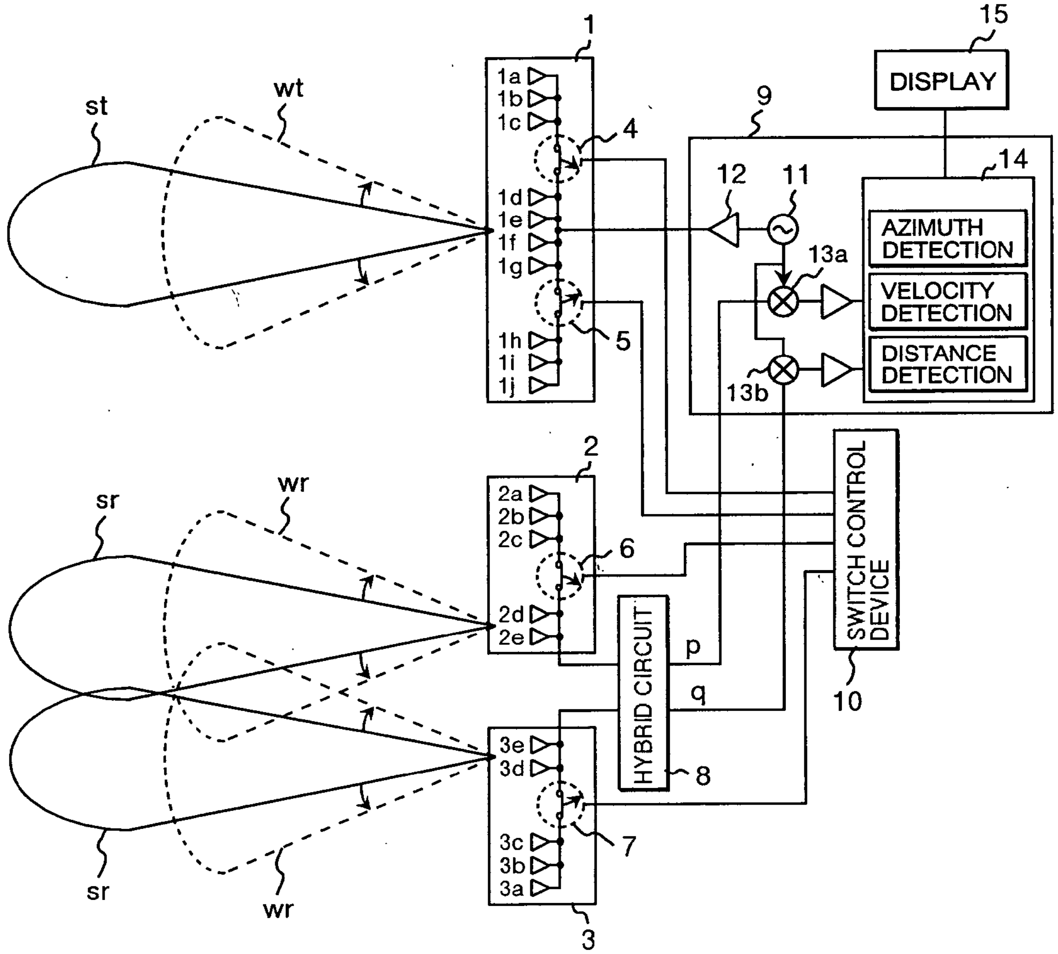
7. A monopulse radar system according to claim 6, wherein:

   when the antenna switch connects or disconnects antenna element groups forming an array antenna, an antenna beam shape is switched to a short angle/long distance or a wide angle/short distance.

8. A monopulse radar system according to claim 6, comprising:

   a switch control device that controls the switching of the antenna switch according to distance between a mobile body and an obstacle.

FIG. 1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1a
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1c
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5
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1i
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wt
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DISPLAY
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14
12
11
AZIMUTH DETECTION
13a
VELOCITY DETECTION
DISTANCE DETECTION
13b
2
2a
2b
2c
6
2d
2e
sr
wr
SWITCH CONTROL DEVICE
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HYBRID CIRCUIT
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q
8
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3b
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sr
wr

FIG. 2

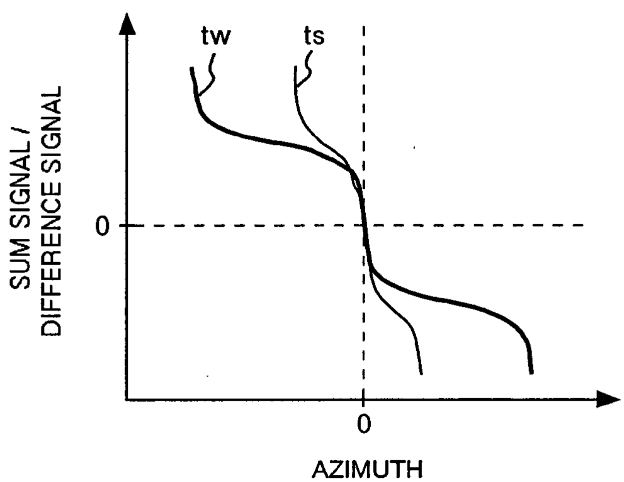
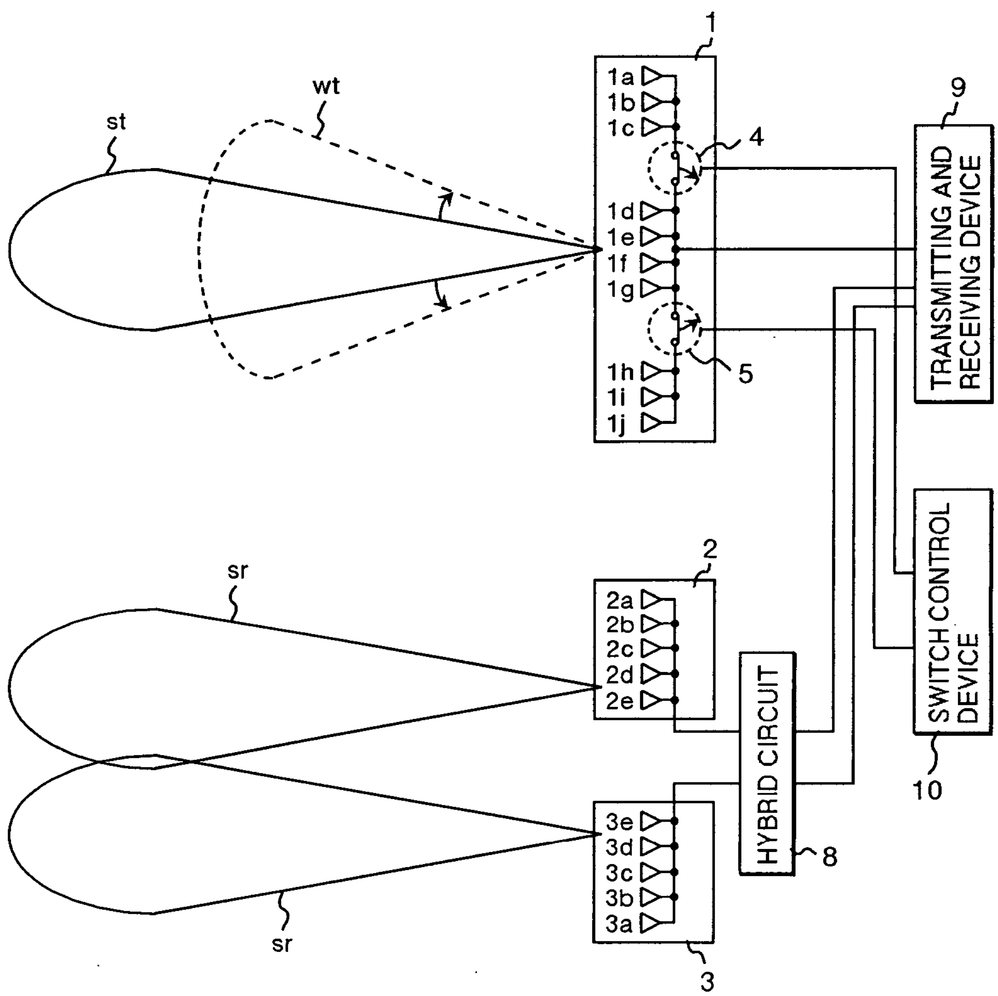


FIG. 3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wt
4
5
9
TRANSMITTING AND RECEIVING DEVICE
SWITCH CONTROL DEVICE
10
2
2a
2b
2c
2d
2e
sr
HYBRID CIRCUIT
8
3e
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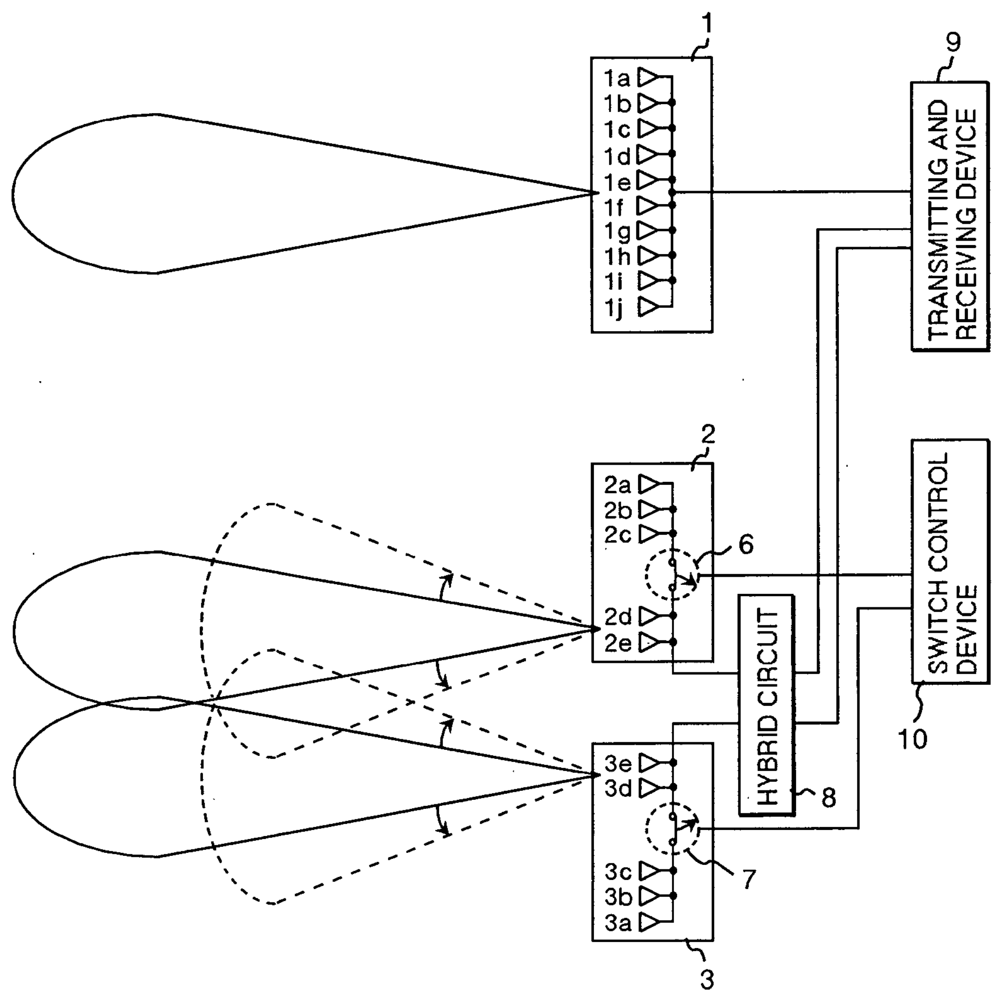
FIG. 4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1c
1d
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1g
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1i
1j
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TRANSMITTING AND RECEIVING DEVICE
2
2a
2b
2c
6
2d
2e
SWITCH CONTROL DEVICE
10
HYBRID CIRCUIT
8
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3d
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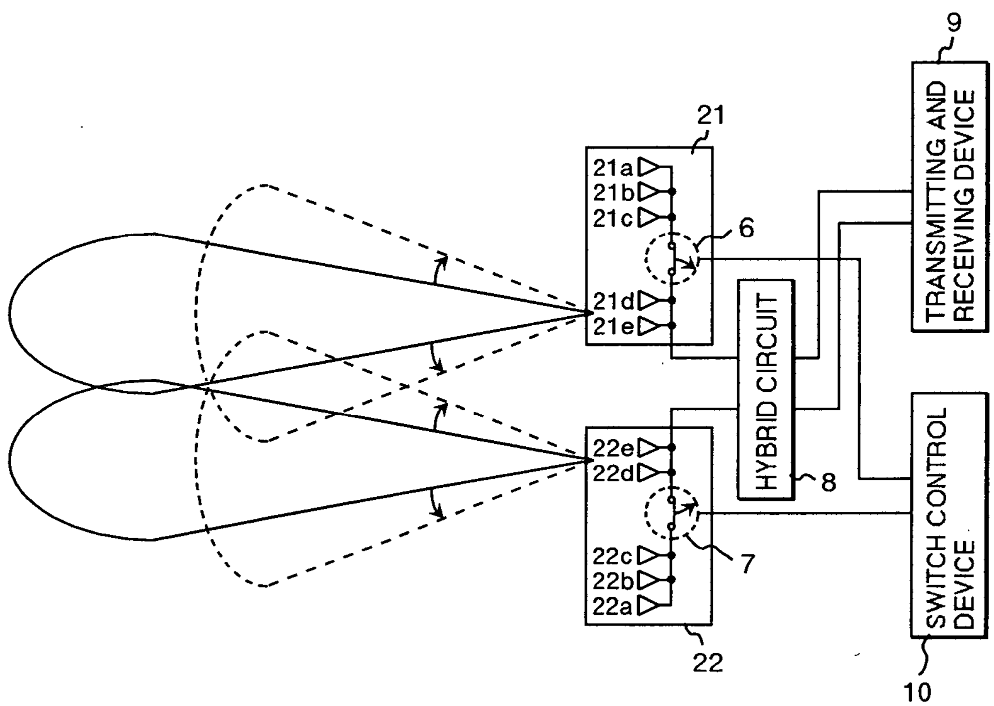
3c
3b
3a
3

FIG. 5


9
TRANSMITTING AND RECEIVING DEVICE
21
21a
21b
21c
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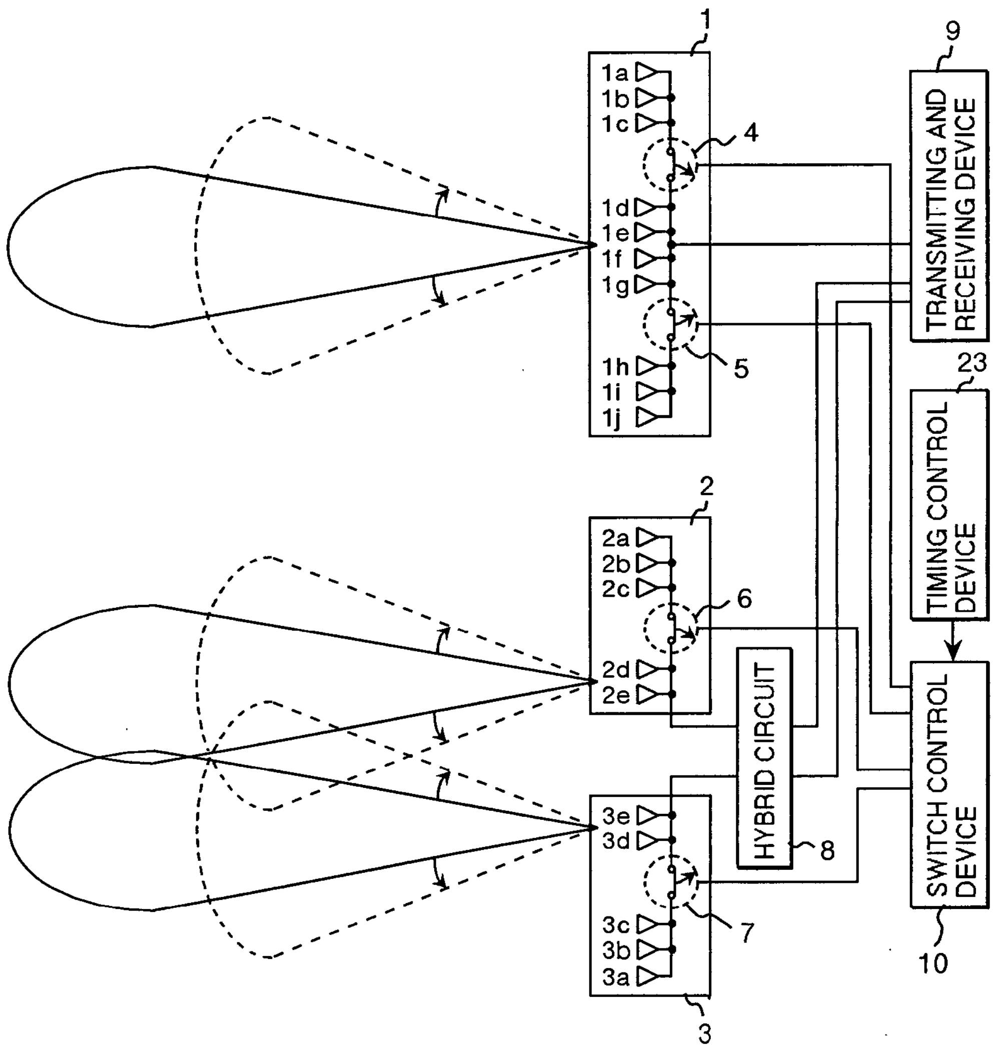
21d
21e
HYBRID CIRCUIT
8
22e
22d
7
22c
22b
22a
22
SWITCH CONTROL DEVICE
10

FIG. 6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1h
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1j
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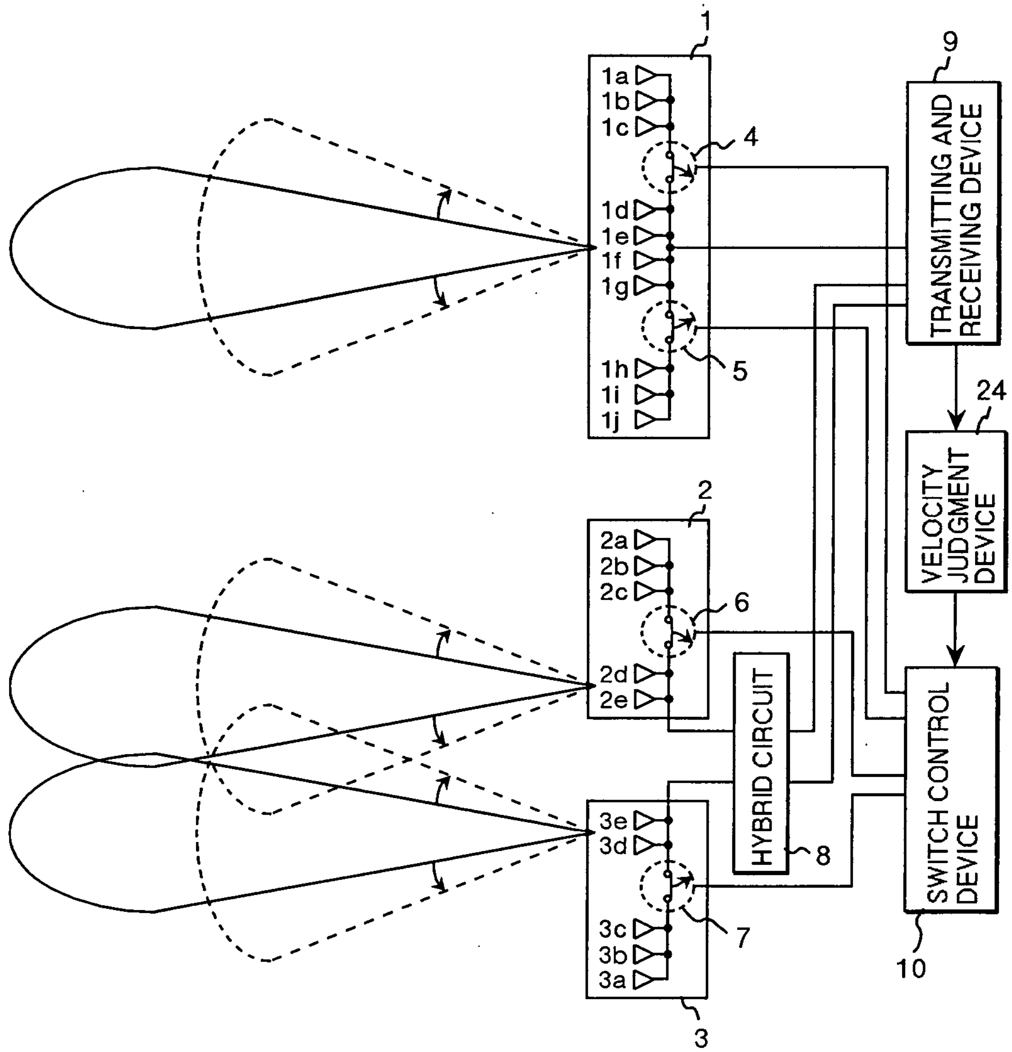
TRANSMITTING AND RECEIVING DEVICE
23
TIMING CONTROL DEVICE
2
2a
2b
2c
6
2d
2e
HYBRID CIRCUIT
8
SWITCH CONTROL DEVICE
10
3e
3d
7
3c
3b
3a
3

FIG. 7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1j
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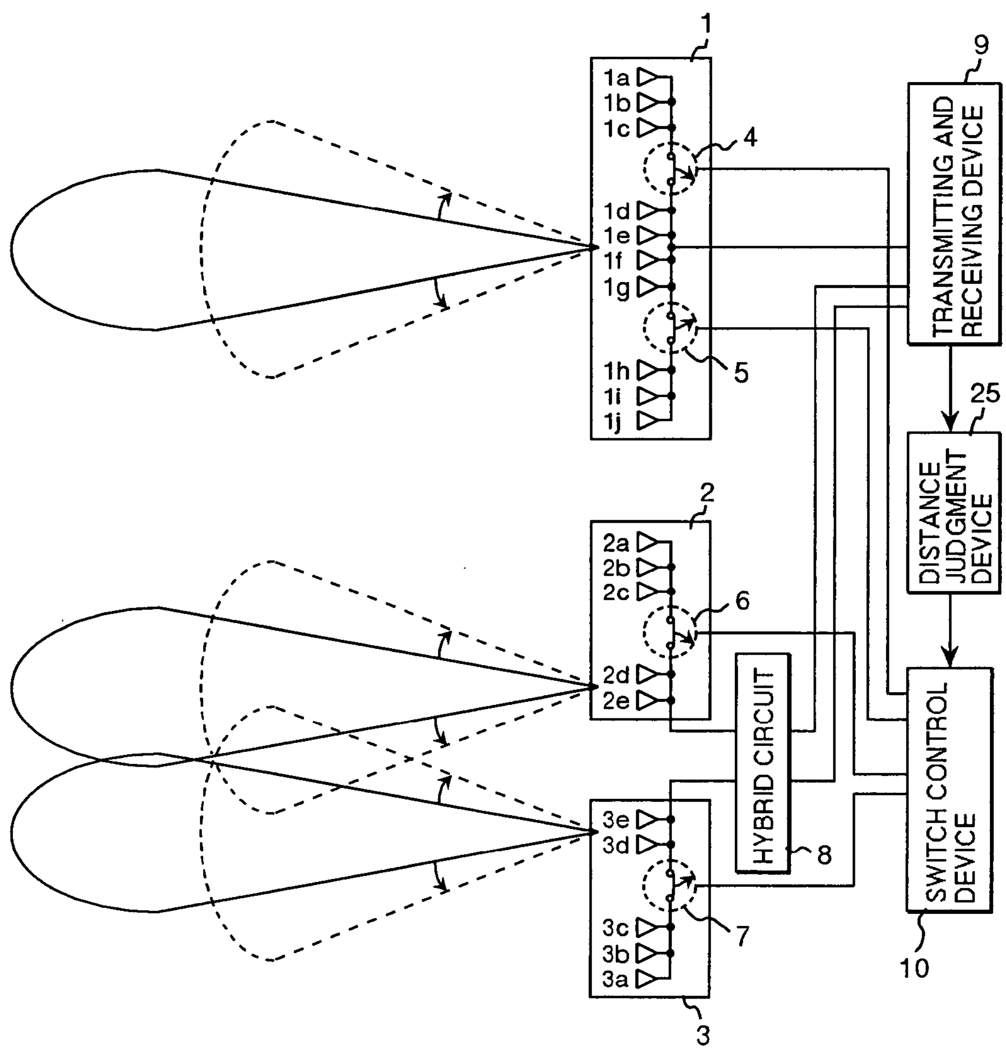
TRANSMITTING AND RECEIVING DEVICE
24
VELOCITY JUDGMENT DEVICE
2
2a
2b
2c
6
2d
2e
HYBRID CIRCUIT
8
SWITCH CONTROL DEVICE
10
3e
3d
7
3c
3b
3a
3

FIG. 8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1d
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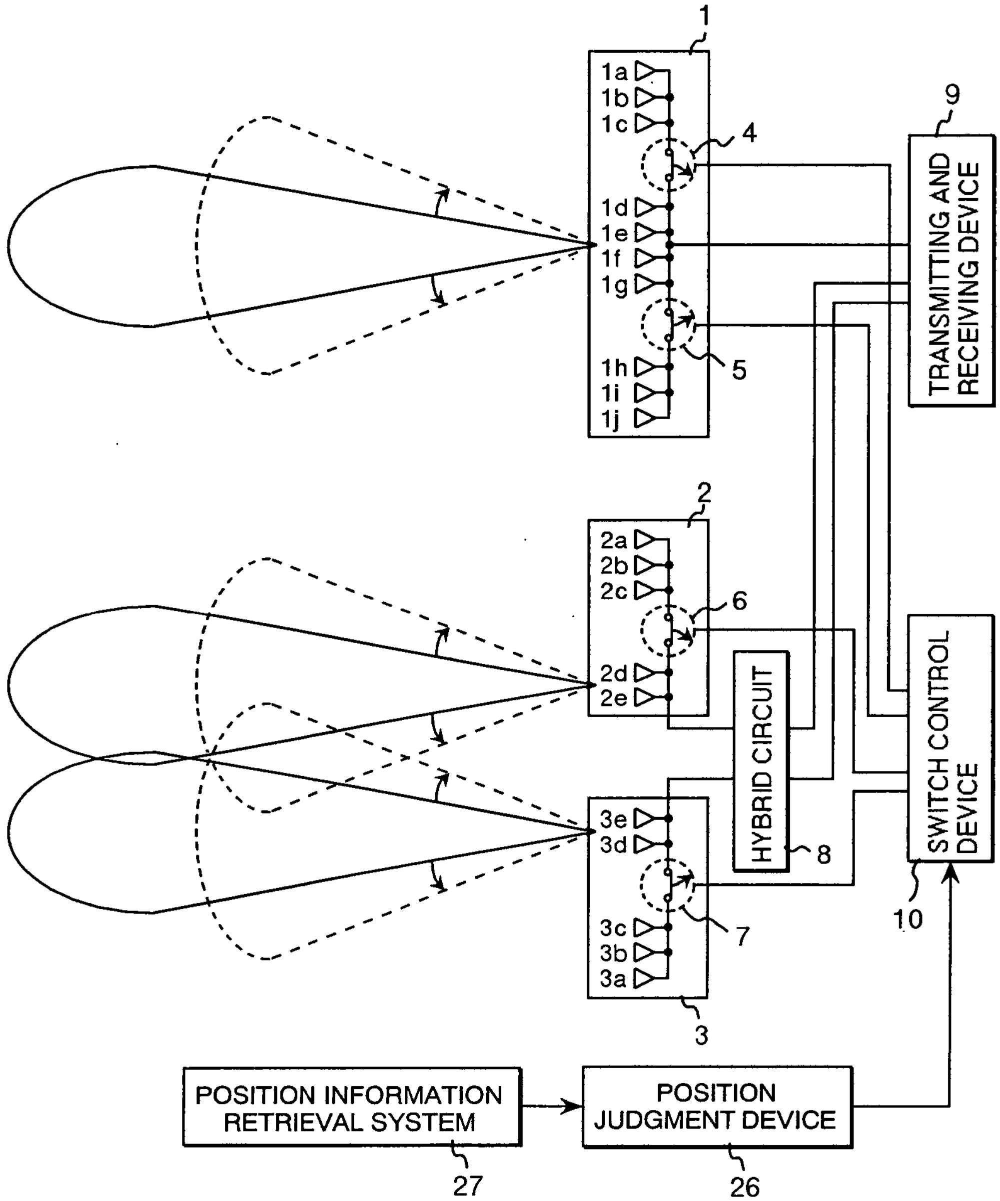
1g
5
1h
1i
1j
9
TRANSMITTING AND RECEIVING DEVICE
25
DISTANCE JUDGMENT DEVICE
2
2a
2b
2c
6
2d
2e
HYBRID CIRCUIT
8
3e
3d
7
3c
3b
3a
3
SWITCH CONTROL DEVICE
10

FIG. 9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1g
5
1h
1i
1j
9
TRANSMITTING AND RECEIVING DEVICE
2
2a
2b
2c
6
2d
2e
HYBRID CIRCUIT
8
3e
3d
7
3c
3b
3a
3
SWITCH CONTROL DEVICE
10
POSITION INFORMATION RETRIEVAL SYSTEM
27
POSITION JUDGMENT DEVICE
26

FIG. 10

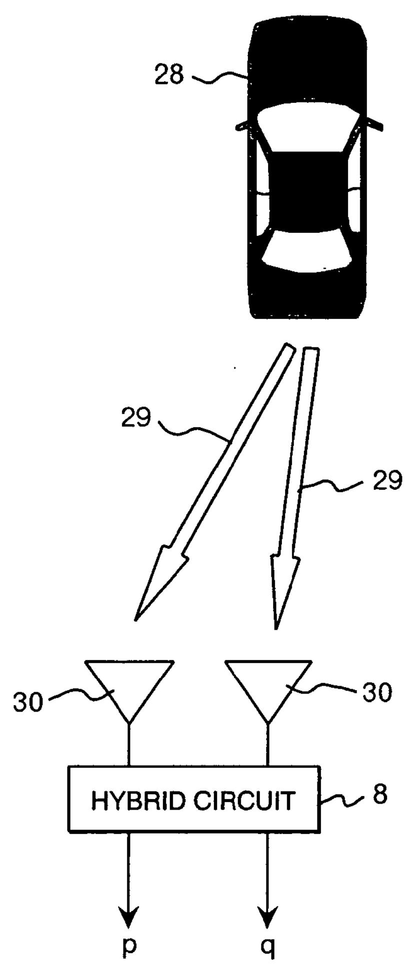
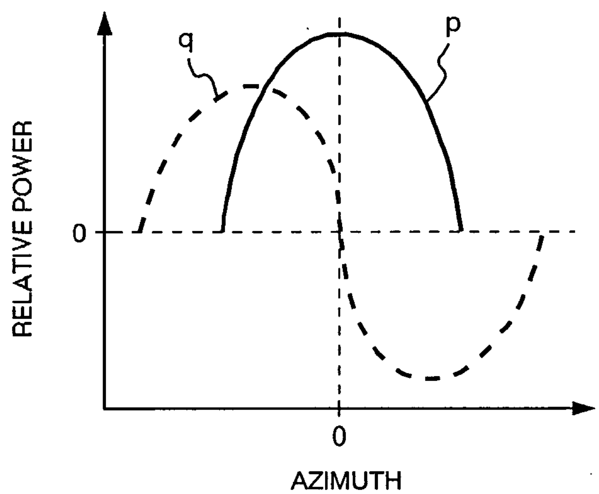


FIG. 11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p
RELATIVE POWER
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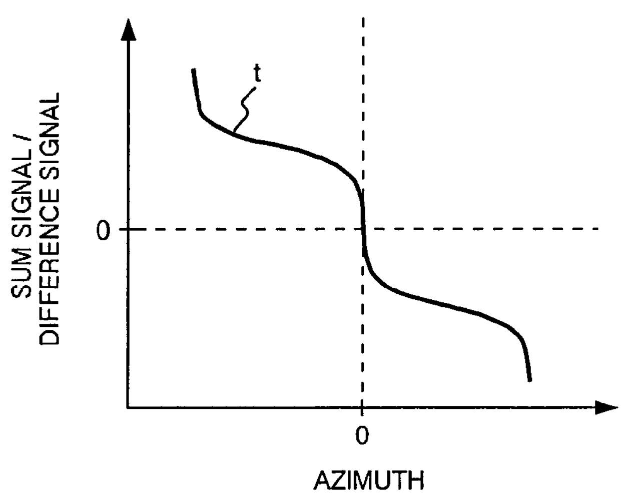
0
AZIMUTH

FIG. 12


t
SUM SIGNAL /
DIFFERENCE SIGNAL
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AZIMUTH

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EUROPEAN SEARCH REPORT

Application Number
EP 02 00 3213

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The present search report has been drawn up for all claims

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MUNICH	6 March 2003	Schmelz, C

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EUROPEAN SEARCH REPORT

Application Number
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